



**Science Analysis Group #6**  
**Cosmic Origins Science Enabled**  
**by the Coronagraph Instrument**  
**on NASA's WFIRST- AFTA**  
**Mission**

Dennis Ebbets, Ken Sembach

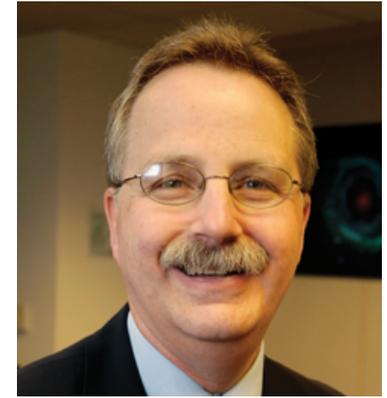
AAS Boston

June 02, 2014

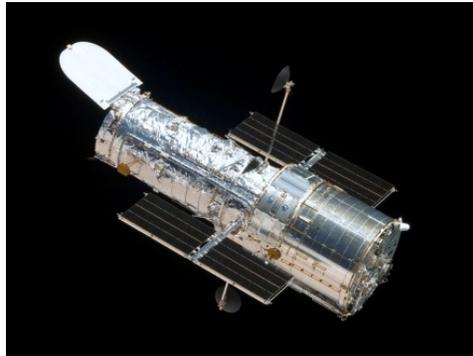
# Purpose of today's discussion

- WFIRST was the highest ranked recommendation for a large space mission made by the 2010 Astrophysics Decadal Survey NWNH
- WFIRST-AFTA is NASA's priority for the next large mission following JWST
- A coronagraph designed to enable exoplanet studies is included in the baseline instrument suite
- **Exploring additional science that this instrument can enable will increase the scientific return and broaden the community of future users**

# Astrophysics Division

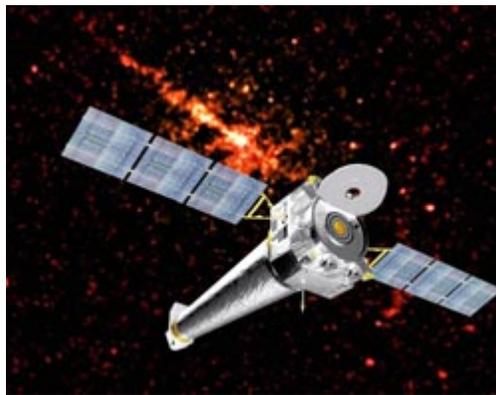


Paul Hertz Director



Hubble

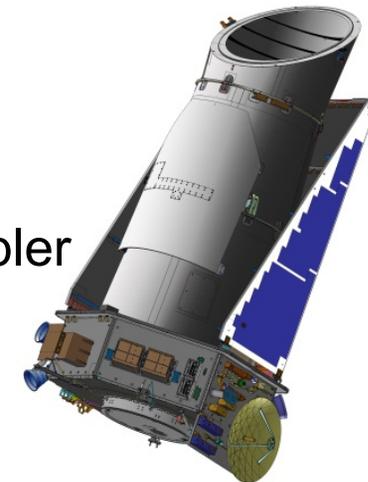
Chandra



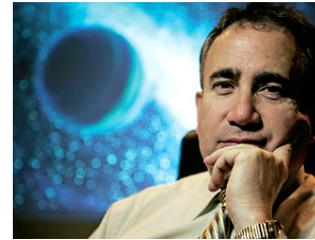
- Cosmic Origins
- Exoplanet Exploration
- Physics of the Cosmos
- Astrophysics Explorers
- Astrophysics Research



Kepler



# Cosmic Origins Program



Mario Perez  
Program Scientist

NASA HQ

- The first stars in the universe
- Dark Matter
- Evolution of Galaxies
- Supermassive Black Holes
- Star and planetary system formation

Michael Garcia  
Deputy Program Scientist



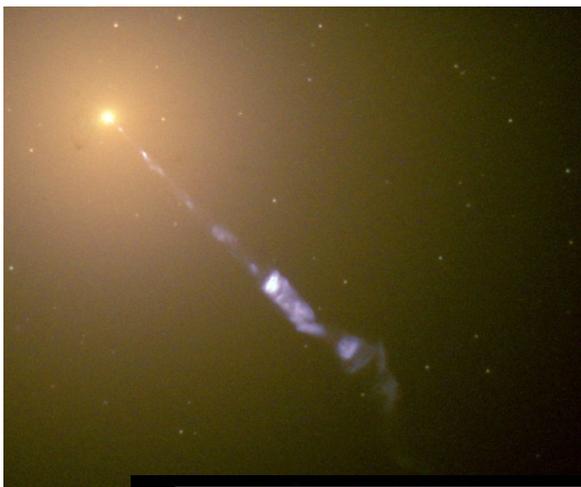
## Cosmic Origins Program Office at GSFC

Program Manager: Mansoor Ahmed  
Chief Scientist: Susan Neff  
Deputy Chief Scientist: Deborah Padgett  
Chief Technologist: Mark Clampin  
Technology Manager: Thai Pham

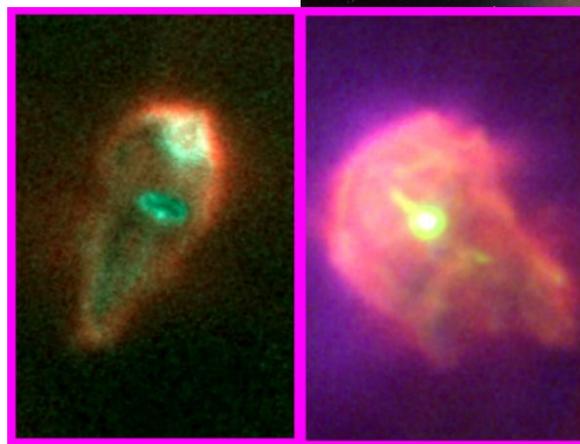
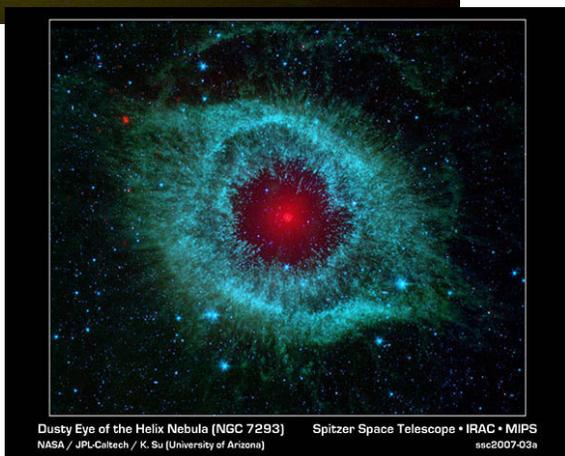
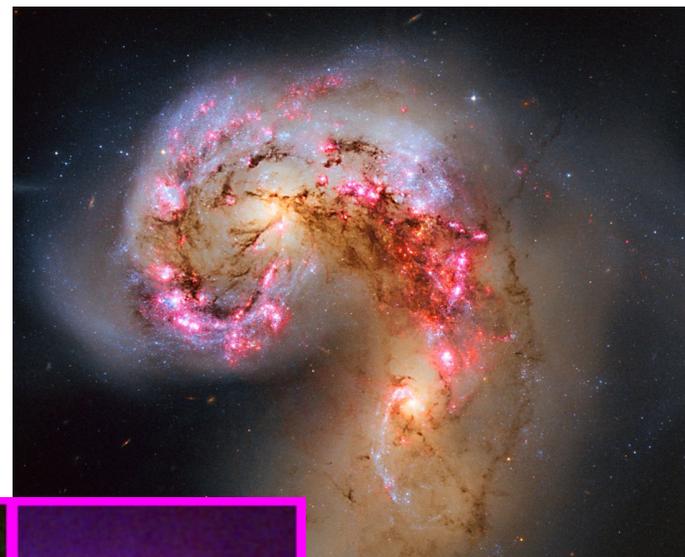
<http://cor.gsfc.nasa.gov/>

# COR maps directly into the science objectives of: 2010 Astrophysics Decadal Survey

## 2013 30 Year Roadmap



Supermassive Black Holes  
Galaxy formation and evolution  
Starbirth  
Protoplanetary systems  
Stellar evolution



# WFIRST – AFTA

## Wide Field InfraRed Survey Telescope Astrophysics Focused Telescope Asset (2.4m telescope)

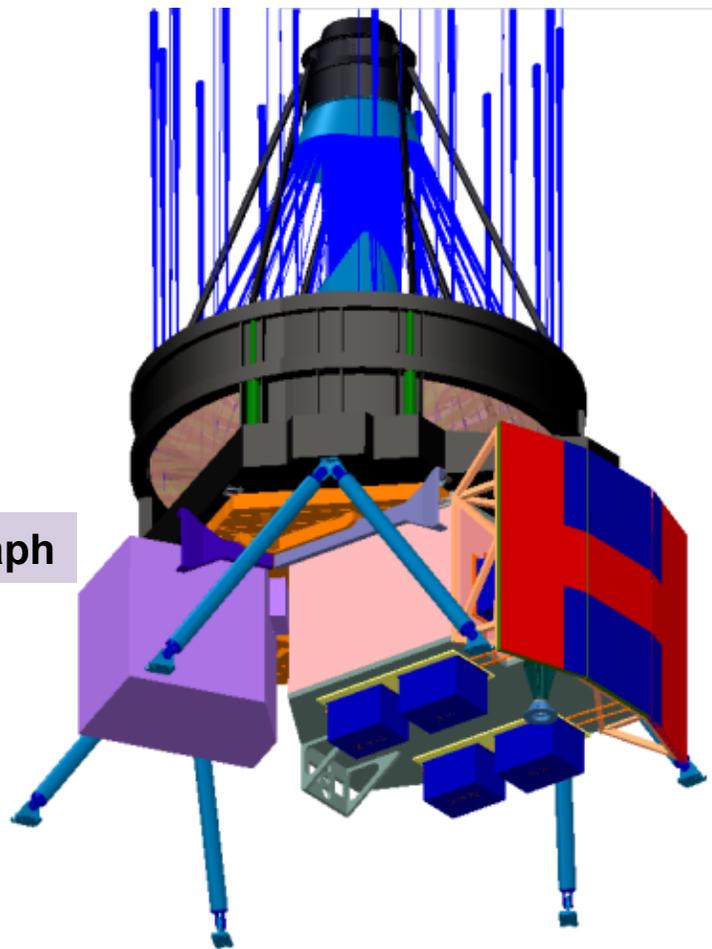


- AFTA Study Office at GSFC
  - Kevin Grady, Neil Gehrels, Dominic Benford
- Exoplanet Exploration Office at JPL
  - Gary Blackwood, Wes Traub
- Science Definition Team
  - David Spergel, Neil Gehrels
- Technology Development
  - Mark Clampin, Peter Lawson
- Phase A FY 2017
- Launch mid 2020s

## Science Objectives

- Large area NIR sky surveys
- Photometric microlensing exoplanet survey
- Dark Energy investigations using WL, BAO, SN Ia
- Coronagraphic exoplanet direct imaging & spectroscopy
- GO investigations

# Attractive characteristics of the AFTA coronagraph



Coronagraph

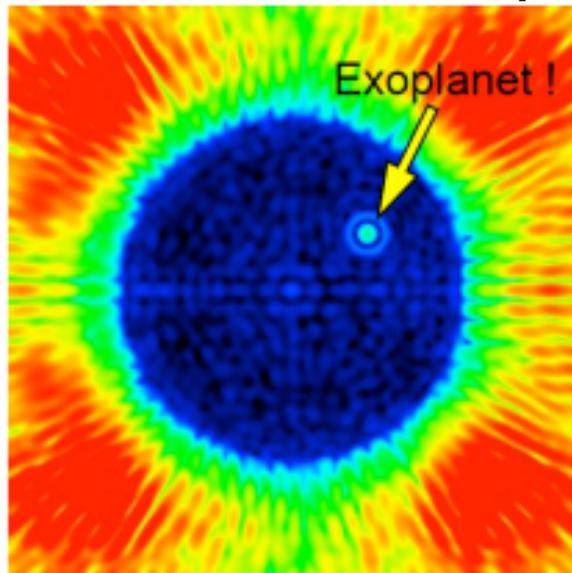
- 2.4 m visible & NIR observatory
- Very good stability, low jitter
- well characterized PSF
  
- 400 – 1000nm spectral coverage
- Central 100 – 250 mas radius occulted
- Contrast  $\sim 10^{-9}$
- Outer FOV about 2 arc sec

Wide Field  
Instrument

# The AFTA Coronagraph

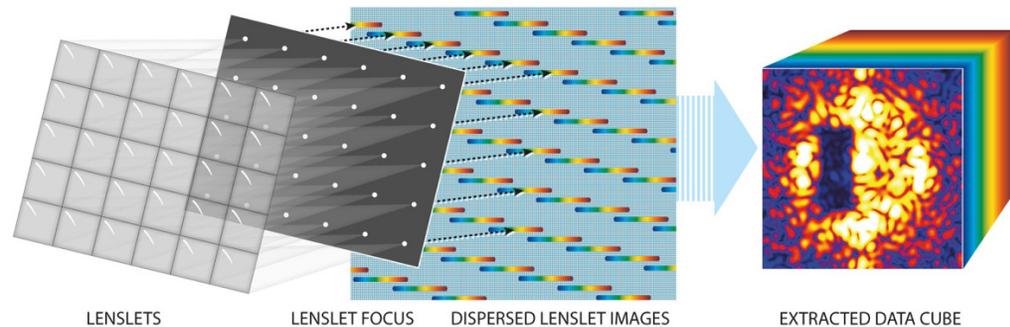
**Occulting Mask Coronagraph = Shaped Pupil + Hybrid Lyot  
(primary)**

**Phase-Induced Amplitude Apodization (backup)**



Direct imaging

1K x 1K Si detector (~CCD)  
5 bands 10% width each



Integral Field Spectrograph

2K x 2K detector (~CCD)  
17 mas / spatial sample  
R ~70

# SAG#6 Cosmic Origins science with AFTA Coronagraph

The Wide-Field Infrared Survey Telescope (WFIRST) is the highest priority large space mission recommended by the recent decadal survey in astronomy and astrophysics. It is designed to perform wide-field imaging and slitless spectroscopic surveys of the visible to near-infrared sky. The Astrophysics Focused Telescope Assets (AFTA) study design of the mission makes use of an existing 2.4m telescope to enhance light collecting and imaging performance. The main instrument is a wide-field multi-filter imager with infrared grism spectroscopy. It also features a small-field low-resolution integral field spectrograph. A coronagraph instrument was part of the study and has a primary science focus of direct imaging of gas-giant exoplanets and debris disks.

The WFIRST-AFTA Science Definition Team has **solicited community input for potential WFIRST-AFTA coronagraphic science investigations related to NASA's Cosmic Origins (COR) theme** or Physics of the Cosmos (PCOS) theme. Such science investigations may further enhance the science case for the AFTA-study design that includes the coronagraph. While not a primary driver for coronagraph design, science investigations other than exoplanet and debris disk studies may provide helpful insight for future design choices.

## Products

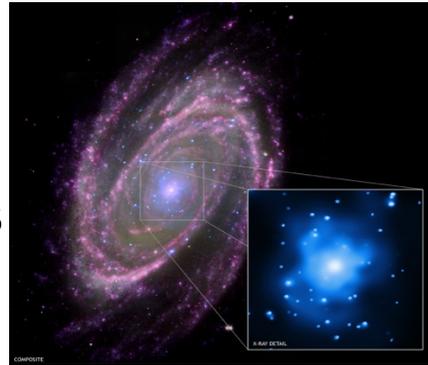
1. Oral briefing to Astrophysics Subcommittee
2. Posting of briefing on COPAG web site

## Schedule

- Initial meeting January 2014 (AAS)
- Soliciting inputs now
- **Public Splinter at June AAS**
- Briefing to Astrophysics Subcommittee late summer / fall 2014
- Written report shortly thereafter

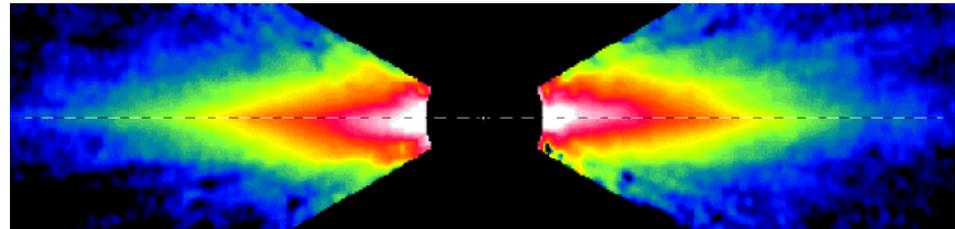
# Examples of Science Investigations

- Quasars & AGN
  - Host galaxies
  - Central black holes
  - Accretion disks
  - Jets



We are hoping that you will help articulate some specific examples

- Young stars
  - Accretion disks
  - Outflows
  - Protoplanetary disks



- Evolved Stars
  - Debris disks
  - Ejecta
  - LBVs -  $\eta$  Carinae
  - WR stars



Previous coronagraph studies identified many examples related to circumstellar environments

- ASMCS studies, Probes, proposals, WFIRST DRMs & SDT reports
- Protostellar nebulae
- Protoplanetary disks
- Disk morphology affected by planets
- Evolved disks
- RG, AGB mass loss
- Shell structures

# Suggestions from previous audiences

- Hosts of IGM absorbers (block light of quasar)
- Are high- $z$  SNe lensed with multiple images or magnification?
- Inner regions of jets from AGN, SMBH etc.
- Collimation of jets from YSOs
- Inner regions of zodiacs of nearby stars
- Bulges of quasar host galaxies
- Faint tidal tails of galaxy mergers
- Multiple shells of LBV and P Cygni stars
- Interactions of stellar winds with circumstellar media
- Light echoes of extragalactic SNe
- Scattering of Ly  $\alpha$  in environs of  $z \sim 6$  quasars

# Here's our request today

- Pick up a brochure
- Take an interest in the activities of the COPAG, ExoPAG and PhysPAG. They influence the space hardware that will be available during your careers.
- Attend & contribute to workshops, townhall meetings, telecons etc. Today's Public Splinter is an example.
- Get on the COPAG mailing list. Go to <http://cor.gsfc.nasa.gov/>  
Click on link in left sidebar.
- Think about the COR science – AFTA coronagraph question.
- Prepare 1 page summary (with nice graphics) & email to: [debbets@ball.com](mailto:debbets@ball.com)

# ROSES 2014 Amendment 15: Release of D.10 WFIRST Preparatory Science (WPS) program

- Open opportunity for funded investigations
- Proposals are due July 11
- Questions concerning D.10, WPS, may be directed to Dominic Benford at [Domestic.Benford@nasa.gov](mailto:Domestic.Benford@nasa.gov)
- If you do propose for coronagraphy science, please send a brief description to this COPAG SAG also. Thanks.

# **Amendment 15: Release of D.10 WFIRST Preparatory Science (WPS) program**

The WFIRST Preparatory Science (WPS) program supports efforts to bridge from basic theory to observational modeling for an implementation of NASA's Wide-Field Infrared Survey Telescope (WFIRST) using the Astrophysics Focused Telescope Assets (AFTA). WFIRST is a NASA observatory designed to perform wide-field imaging and slitless spectroscopic surveys of the near infrared sky in response to the recommendation from the 2010 Decadal Survey of Astronomy and Astrophysics. The current WFIRST-AFTA design of the mission makes use of an existing 2.4 m telescope which, with its concomitant enhancement of sensitivity and imaging performance, may also be equipped to perform coronagraphic imaging and spectroscopy of exoplanets. A description of the present WFIRST-AFTA design concept and its primary scientific investigations is provided in the recent reports of the WFIRST Science Definition Team, available online at <http://wfirst.gsfc.nasa.gov>